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TECHNICAL REPORT EHL (W) 83-13

AD A138364

SUPPLEMENTARY INDUSTRIAL HYGIENE DATA FOR F-16 AIRCRAFT REFUELING INSIDE CLOSED AIRCRAFT SHELTERS

JULY 1983

FINAL REPORT
MAY 1983 - JULY 1983

APPROVED FOR PUBLIC RELEASE;
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20030109254

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER Technical Report EHL(W) 83-13	2. GOVT ACCESSION NO. AD-A138364	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Supplementary Industrial Hygiene Data For F-16 Aircraft Refueling Inside Closed Aircraft Shelters		5. TYPE OF REPORT & PERIOD COVERED Final Report May 1983 - July 1983
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) David J. Hawkins, TSgt, USAF Joseph A. Martone, Major, USAF, BSC		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS USAF Regional Medical Center Wiesbaden/SGB APO New York 09220		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS USAF Regional Medical Center Wiesbaden/SGB APO New York 09220		12. REPORT DATE July 1983
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Availability of this report is specified on reverse of front cover

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aircraft shelters	Fuel vapors	Aircraft
Jet fuel	Industrial hygiene	Aviation fuel
Refueling	Exposure	Charcoal tubes
Integrated combat turns	Carbon Monoxide	Monitoring

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report supplements EHL(W) TR 83-08, "An Industrial Hygiene Evaluation of F-16 Aircraft Refueling Inside Closed Aircraft Shelters". This study considers F-16 refueling inside third generation shelters using JP-8 was well as JP-4 fuel. The position of the fuel truck differed from previous work. Workplace concentrations of fuel vapors, carbon monoxide, and benzene were measured. The conclusion is that F-16 refueling in third generation shelters need not be limited because of industrial hygiene considerations.

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PREFACE

This industrial hygiene study is part of an on-going NATO evaluation of aircraft refueling in closed aircraft shelters. The report presents supplementary data and analysis for F-16 aircraft. This subject was considered initially in Technical Report EHL (W) 83-08. Two other reports, BEES(W) 81-03 and BEES(W) 81-42 also present relevant information.

The report includes data obtained at Volkel AB, Holland during the week of 24 May 83. The study involved many NATO and USAF personnel in addition to our bioenvironmental team. Special gratitude is extended to Mr. Walter Will at HQ USAFE/DEMO for his role in coordinating the entire effort.

Individuals from the USAF Regional Medical Center Wiesbaden making significant contributions to this industrial hygiene evaluation and this report are:

MSgt Gary W. Sirucek, Technician
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Ms. Katherine D. Barnett, Secretary

This report has been reviewed by the public affairs officer and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

Headquarters USAFE/DEMO requested the USAF Regional Medical Center Wiesbaden to conduct industrial hygiene surveys as part of a NATO evaluation of aircraft refueling inside closed aircraft shelters. This report presents results of F-16 aircraft tests using JP-4 or JP-8 fuel in third generation shelters. Previous related work is described in References 1, 2, and 3. Since procedures and analysis methods were essentially unchanged from earlier work these factors are only briefly described.

During the tests, representatives from Technischer Uberwachungs-Verein (TUV) Rheinland made fuel vapor measurements near the aircraft fuel tank vents to define the explosive hazard region. These results are not included but should be available from HQ USAFE/DEMO, APO NY 09012.

SECTION II

TEST DESCRIPTION

Table 1 summarizes test conditions. All refueling was done with a diesel powered fuel truck located completely inside a closed, unventilated third generation shelter. JP-8 (NATO F-34) fuel was used for Test A and JP-4 (NATO F-40) fuel was used for Tests B and C. For Test B the JP-4 fuel was transferred to an aircraft which had about 0.9 m^3 residual JP-8 fuel in its fuel tank. For each test the aircraft was brought to the shelter after return from a mission to assure realistic fuel tank conditions (i.e. temperature, volume of fuel remaining etc.)

The time required to fill F-16 fuel tanks was about five minutes. The fuel vapor exposure time for crew members was considered as the elasped time between initiating fuel flow and the time the shelter doors were opened post test. The exposure time was seven to ten minutes (see Table 1).

TABLE 1

F-16 IN-SHELTER REFUELING TEST CONDITIONS

TEST	AMBIENT AIR TEMP. (°C)	FUELING TIME (min)	EXPOSURE TIME (min)	VOLUME OF FUEL TRANSFERRED (m^3)
A	13.3	5	10	3.3
B	12.2	5	7	3.8
C	12.8	5	9	3.3

SECTION III

INDUSTRIAL HYGIENE CONSIDERATIONS AND TEST PROCEDURES

Contaminants released into the work environment included fuel vapor displaced from the aircraft fuel tank and certain combustion products exhausted by the diesel fuel truck. Fuel vapor and carbon monoxide (CO) concentrations were measured using procedures described in Reference 3. Breathing zone samples and bulk fuel samples were analyzed for benzene. Carbon monoxide measurements were made at a single fixed location. On Test A, CO was measured in the left rear quadrant of the shelter; on Tests B and C, CO was measured about 2 meters from the fuel truck exhaust pipe.

The most significant differences between this work and the tests discussed in Reference 3 are that in this work: a) A larger shelter provided increased pollutant dilution volume, b) JP-8 was used in addition to JP-4, c) The fuel truck was nosed into the shelter on the same side of the aircraft as the fuel tank vent rather then backed into the shelter on the side opposite the fuel tank vent. This last condition meant that the hot fuel truck exhaust pipe was much closer to the aircraft fuel tank vent than was the case for earlier work. This change may be an important safety consideration, but it was not expected to have much impact on the industrial hygiene measurements.

Because of the short time required for an in-shelter refueling the health criteria which best applies is the short term exposure limit (STEL) Table 2 lists the STEL's and the workday time weighted average limit (PEL) for chemical substances considered in this study. A more thorough discussion of applicable health criteria is given in Reference 3.

TABLE 2

HEALTH CRITERIA FOR SELECTED CHEMICAL SUBSTANCES

SUBSTANCE	PEL	STEL
CO	50 ppm	400 ppm
Benzene	30 mg/m^3	75 mg/m^3
Fuel Vapors	350 mg/m^3	1800 mg/m^3

SECTION IV

RESULTS AND DISCUSSION

1. Carbon monoxide

No CO was detected on Test A. The average CO levels measured on Test B and C were 10 ppm and 33 ppm respectively. The higher levels measured on Test B and C were expected since the measurement location was much closer to the fuel truck exhaust point than for Test A. The average CO concentrations were well below the CO STEL and PEL. It is noteworthy that the smoke and irritants associated with diesel exhaust did not cause significant discomfort in any of the tests.

2. Fuel vapors

Table 3 gives breathing zone concentrations of total fuel vapors. Results are reported in milligrams fuel vapor per cubic meter of air. The concentrations shown on Table 3 are calculated as a 15 minute average concentration even though actual exposure times were 7-10 minutes. This approach allows direct comparison of results with the STEL which by definition is a 15 minute average concentration. For each sample, the benzene concentration was below the detectable limit of 3.3 mg/m^3. The benzene content of bulk fuel samples was 1.0, 0.9, and 1.5 volume percent for Tests A, B, and C respectively.

In Table 3 "fueler" refers to the person who performed the connection, monitoring and disconnection of the fuel hose at the aircraft, "fuel truck technician" refers to the person stationed at the fuel truck, and "area" refers to a bioenvironmental engineering team member.

TABLE 3 BREATHING ZONE FUEL VAPOR MEASUREMENTS

Sample Location	Measured Fuel Vapor Concentration (mg/m^3)		
Test:	A	B	C
fuel truck technician	13.3	46.6	86.6
fueler	6.7	100	60.0
area	6.7	23.3	60.0
Average	8.9	56.6	68.9

Figure 1 in Reference 2 is a graphical correlation of ambient air temperature and fuel vapor concentration developed from previous measurements. Using this graph, the predicted average fuel vapor concentration for Test C is 52 mg/m^3. This prediction agrees quite well with the average measured value of 68.9 mg/m^3. Prediction is possible only for Test C since the correlation was developed for JP-4 vapor and Test A involved JP-8 vapor and Test B a mixture of JP-4 and JP-8 vapor.

Reference 3 noted that, for the F-16, predicted fuel vapor concentrations are probably less than measured values because the relatively high exposures which occur near the single point fuel system vent tend to skew the average measured concentration. The prediction correlation of Reference 2 was based on data obtained during refueling of aircraft which had fuel systems with multiple vents. Table 3 shows that on two tests the fuel truck technician had the greatest exposure; Reference 3 showed the fueler to consistently have the highest exposure. This change is due to the fuel truck technician being stationed much closer to the fuel vent on these tests and to the fact that the fueler performed aircraft checks during refueling and did not stand fixed at the refueling point as was the case for the previous F-16 tests.

Table 3 shows exposure well below the fuel vapor STEL and PEL. The measured JP-4 levels (i.e. Test C) are lower than those measured during Reference 3 tests because of the additional dilution volume available in a third generation shelter compared to a first generation shelter (i.e. fuel transfer volumes and ambient air temperatures were about the same for both tests so shelter volume was the only significant factor affecting breathing zone fuel vapor concentrations). The concentrations measured on Test A are much lower than for the other tests because JP-8 has a vapor pressure much lower than JP-4 (Reference 4).

Based on these results there should be no restriction on refueling F-16 aircraft in closed third generation shelters. Reference 3 made the same conclusion for first generation shelters.

SECTION V
CONCLUSION AND RECOMMENDATION

Based on industrial hygiene considerations, F-16 aircraft refueling can be performed in closed hardened aircraft shelters without limitation. This finding does not eliminate the need for workplace industrial hygiene good practice and periodic monitoring at the local level. This report should serve as useful guidance for USAFE medical treatment facility personnel when planning and performing industrial hygiene surveys of in-shelter refueling.

REFERENCES

1. Martone, Joseph A., "An Industrial Hygiene Evaluation of Aircraft Refueling Inside Closed Aircraft Shelters ," BEES (W) - TR-80-03, January 1981.

2. Martone, Joseph A.. "An Industrial Hygiene Evaluation of Aircraft Refueling Inside Closed Aircraft Shelters at Elevated Ambient Temperatures," BEES (W) - TR-81-42, October 1981.

3. Martone, Joseph A., "An Industrial Hygiene Evaluation of F-16 Aircraft Refueling Inside Closed Aircraft Shelters," EHL(W) TR 83-08, July 1983.

4. Lewanodowski, G.H. and Stauffer, T.B., "Control of JP-4 Emissions from Underground Storage Tanks," ESL-TR-74-03, April 1979

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